January 1994

Physics 30

Grade 12 Diploma Examination

Alberta
EDUCATION

January 1994

Physics 30

Grade 12 Diploma Examination

Description

Time allotted: 2.5 h. You may take an additional 0.5 h to complete the examination if needed.
Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

Part A
has 42 multiple-choice questions each with a value of one mark.

Part B
has 7 numerical-response questions each with a value of one mark.

Part C
has 4 written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Carefully read the instructions for each part before proceeding.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Do not fold the answer sheet.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Part A: Multiple Choice

42 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully and decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This diploma examination is for the subject of

A. biology
B. physics
C. chemistry
D. mathematics

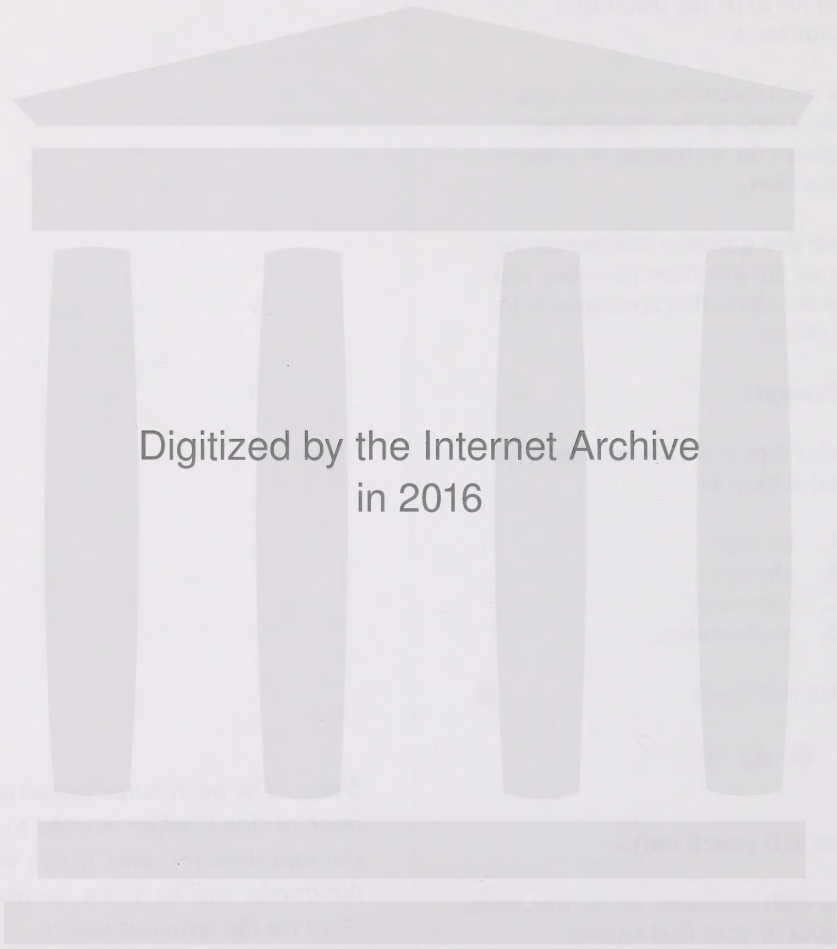
Answer Sheet

Ⓐ ● Ⓒ Ⓓ

- **Use an HB pencil only.**
- If you wish to change an answer, erase **all** traces of your first answer.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Do not turn the page to start the examination until told to do so by the presiding examiner.

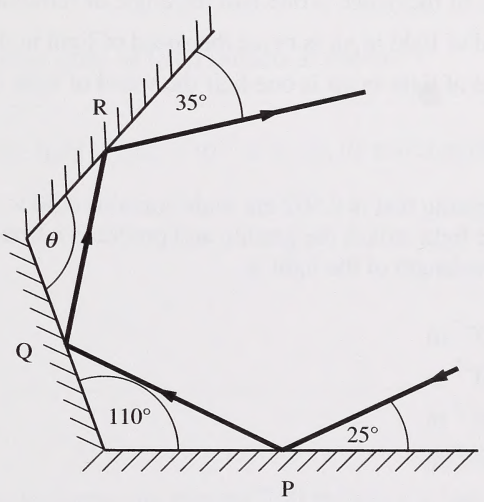


1. The alternate dark and bright bands that are produced when light passes through a double slit are caused by

A. polarization
B. interference
C. dispersion
D. refraction

Use the following information to answer question 2.

Law of Reflection



Three plane mirrors P, Q, and R are arranged as shown. The incident ray strikes mirror P at an angle of 25° and leaves mirror R at an angle of 35°.

2. The angle θ between mirrors Q and R is

A. 90°
B. 100°
C. 110°
D. 120°

3. The color of an opaque object is determined by the light it

   A. diffracts
   B. scatters
   C. refracts
   D. reflects

4. A ray of light in air enters obliquely into a medium with a refractive index of 2.0. What is indicated by the refractive index of 2.0?

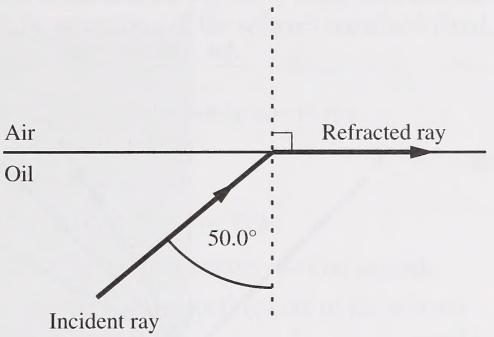
   A. The angle of incidence is twice the angle of refraction.
   B. The angle of incidence is one-half the angle of refraction.
   C. The speed of light in air is twice the speed of light in the medium.
   D. The speed of light in air is one-half the speed of light in the medium.

5. A diffraction grating that is 0.502 cm wide contains 4.50×10^3 lines. A beam of monochromatic light strikes the grating and produces a first-order image at an angle of 22.0°. The wavelength of the light is

   A. 4.18×10^{-7} m
   B. 8.36×10^{-7} m
   C. 4.18×10^{-5} m
   D. 8.36×10^{-5} m

Use the following information to answer question 6.

Critical Angle



A ray of light travelling from oil to air refracts as shown.

6. If the wavelength of the light is 6.02×10^{-7} m in air, its wavelength in oil was

A. 7.86×10^{-7} m
B. 6.02×10^{-7} m
C. 4.61×10^{-7} m
D. 3.87×10^{-7} m

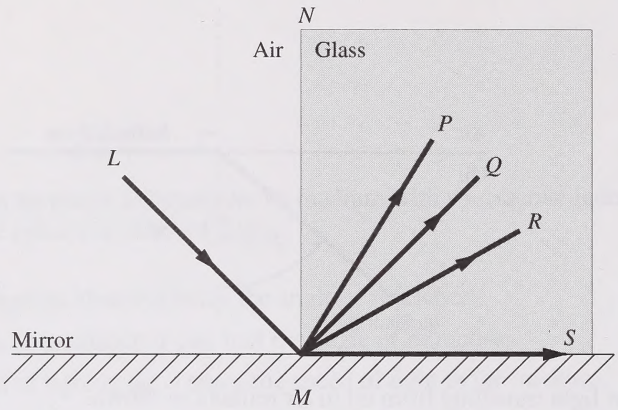
---

7. In a first double-slit experiment, the slits are 2.00 m from a screen that is 1.00 m × 1.00 m in size. In a second double-slit experiment, the distance from the slits to the screen is doubled and the area of the screen is doubled; other factors are unchanged. Compared to the first experiment, the distance between adjacent bright fringes in the second experiment is

A. halved
B. doubled
C. unchanged
D. quadrupled

Use the following information to answer question 8.

Reflection and Refraction



A block of glass rests on a mirror. A ray of light travelling in air is incident on the reflecting surface at point *M*, where the glass, the air, and the mirror surface meet. The angles *NML* and *NMQ* are equal in magnitude.

8. The reflected ray is represented by the line

A. *MP*
B. *MQ*
C. *MR*
D. *MS*

---

9. On a sunny day, Polaroid™ sunglasses reduce glare from the surface of a lake primarily because they

A. reflect a proportion of the incident light
B. refract a proportion of the incident light
C. absorb a proportion of the reflected light
D. absorb a proportion of the ultraviolet light

Use the following information to answer question 10.

In an experiment designed to investigate the electric force between two small charged spheres, it was found that the repulsive force between the spheres gradually decreased even when the separation of the spheres remained fixed.

10. This change in repulsive force was probably due to the

A. charge on the spheres being lost
B. interaction with the Earth's magnetic field
C. individual charges using up their energy as time passed
D. movement of charges on the conducting coat of the spheres

---

11. An instrument used to detect the presence of static electric charges is the

A. compass
B. photocell
C. electroscope
D. current balance

12. The electrostatic force between two protons 2.0×10^{-10} m apart is

A. 1.2×10^{-18} N
B. 5.8×10^{-9} N
C. 2.3×10^{9} N
D. 9.0×10^{9} N

Use the following information to answer question 13.

Field Properties

I. vectors
II. measured in newtons
III. vary inversely as the square of the distance from the source
IV. vary directly as the distance from the source

13. Both electric and gravitational fields from point sources have properties

A. I and III
B. I and IV
C. II and III
D. II and IV

---

14. A fixed resistance of 11.0 Ω is connected to a 117 V supply. How much charge will pass through this resistor in 1.00 min?

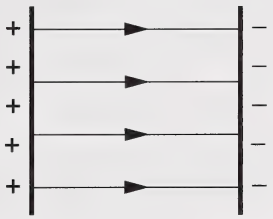
A. 660 C
B. 638 C
C. 21.5 C
D. 10.6 C

15. Which of the following combinations can be used to represent electric potential difference?

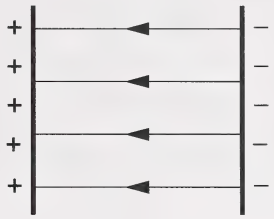
A. Charge/force
B. Force/charge
C. Charge/work
D. Work/charge

16. The direction of the electric field between two charged, parallel, metal plates is shown by

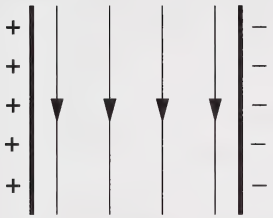
A.



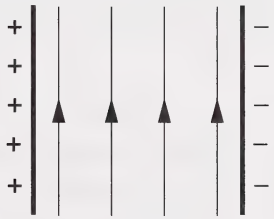
B.



C.



D.



17. In the absence of other forces, a charged particle entering an electric field will

A. change both its velocity and its kinetic energy
B. maintain both its velocity and its kinetic energy
C. maintain its velocity but change its kinetic energy
D. change its velocity but maintain its kinetic energy

18. An electron moving perpendicularly through a magnetic field of magnitude 5.0 T experiences a deflecting force of 4.0×10^{-13} N. The speed of this electron is

A. 5.0×10^{5} m/s
B. 5.8×10^{5} m/s
C. 1.3×10^{7} m/s
D. 2.5×10^{7} m/s

19. Ohm's law can be expressed in the form $V = IR$. Units that may be used for V, I, and R, respectively, are

A. voltage, current, and resistance
B. volt, coulomb, and ohm
C. joule, ampere, and ohm
D. volt, ampere, and ohm

20. A proton and an electron travelling at the same velocity enter a magnetic field at right angles to the field. Compared to the electron's deflection, the proton's deflection will be in the

A. same direction, with a smaller radius of curvature
B. opposite direction, with a smaller radius of curvature
C. opposite direction, with a larger radius of curvature
D. same direction, with a larger radius of curvature

21. Using a mechanical model for the ether, Maxwell assumed the speed of electromagnetic wave propagation to be dependent upon the

A. stiffness and density of the medium
B. frequency and intensity of the wave
C. wavelength and amplitude of the wave
D. temperature and density of the medium

22. Electromagnetic radiation of wavelength 250 m is classified as

A. radio
B. gamma
C. infrared
D. ultraviolet

Use the following information to answer questions 23 and 24.

A current I passes through a coil. The energy E stored in the magnetic field of the coil can be calculated using the equation $E = \frac{1}{2}LI^2$, where L is a symbol for *inductance*.

23. A particular coil stores 4.6×10^{-3} J when a 0.36 A current flows. The numerical value of the inductance L in SI units is

A. 78
B. 0.27
C. 7.1×10^{-2}
D. 2.6×10^{-2}

24. What are the SI units for the inductance L?

A. Ω
B. J/A
C. W/A^2
D. J/A^2

---

25. A hot burner on an electric kitchen stove **mostly** emits

A. gamma radiation
B. infrared radiation
C. ultraviolet radiation
D. microwave radiation

26. Which group of compounds **best** demonstrates the Law of Multiple Proportions?

A. NO, NO_2, N_2O

B. NO_2, NH_3, NI_3

C. CO_2, H_2O, BaO

D. CH_4, CCl_4, CBr_4

27. A current of 15.0 A passes through a solution and deposits 16.0 g of an element in a period of 25.0 min. If the ionic charge of the element is 2+, its atomic mass is

A. 41.1 g/mol

B. 69.6 g/mol

C. 82.3 g/mol

D. 137 g/mol

28. An electron makes a transition from an orbit where its energy is -4.0 eV to another orbit where its energy is -12.0 eV. The wavelength of the emitted photon is

A. 7.7×10^{-8} m

B. 1.0×10^{-7} m

C. 1.6×10^{-7} m

D. 3.1×10^{-7} m

29. To determine the speed of cathode-ray particles, which two forces did J.J. Thomson balance?

A. Potential and kinetic
B. Electrical and magnetic
C. Gravitational and magnetic
D. Gravitational and electrical

30. In a Millikan-type experiment using a negatively charged oil drop, the positive electric plate must be placed

A. above the negative plate
B. below the negative plate
C. to the left of the negative plate
D. to the right of the negative plate

31. An ion with a charge of 2+ enters perpendicularly to a magnetic field of strength 0.12 T. If the speed of the ion is 2.4×10^4 m/s and it follows an arc of radius 9.4×10^{-3} m, the mass of the ion is

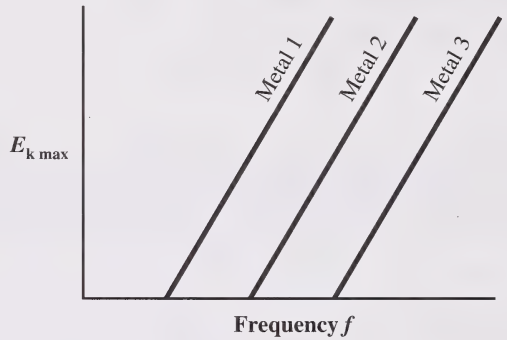
A. 9.2×10^{-16} kg
B. 1.5×10^{-26} kg
C. 7.5×10^{-27} kg
D. 6.7×10^{-27} kg

32. An X-ray tube produces photons by accelerating an electron through a potential difference and then having the electron collide with a metal surface. The minimum potential difference necessary to produce a photon of a wavelength of 2.0×10^{-10} m is

A. 8.3×10^{-25} V
B. 9.9×10^{-18} V
C. 6.2×10^{3} V
D. 1.3×10^{9} V

Use the following information to answer question 33.

Maximum Kinetic Energy of Photoelectrons as a Function of Frequency

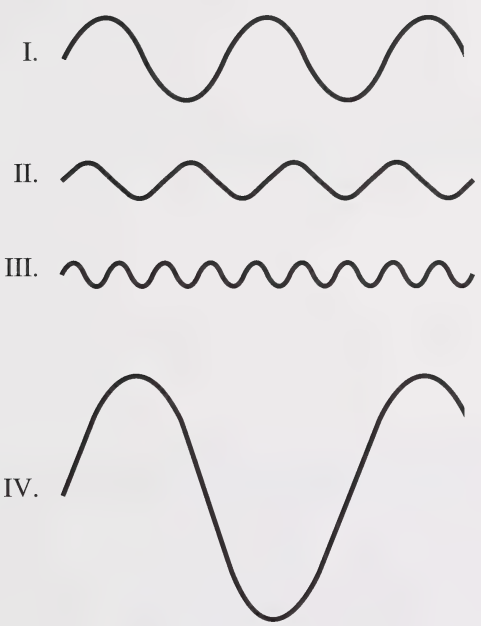


33. The graph illustrates that

A. for a given frequency of incident light, photoelectrons emitted from metal 2 have more kinetic energy than those emitted from metal 1
B. the maximum kinetic energy of emitted photoelectrons is dependent upon the intensity of the incident light
C. metals will emit photoelectrons only if the intensity of the incident light is greater than some critical value
D. metals will emit photoelectrons only if the frequency of incident light is greater than some critical value

Use the following information to answer question 34.

These diagrams represent four electromagnetic waves incident upon the same metal surface.



Amplitude is plotted vertically and time is plotted horizontally. All diagrams are drawn to the same scale.

34. Photoelectrons with the greatest kinetic energy would be emitted as the result of wave

A. I
B. II
C. III
D. IV

35. The radius of the second hydrogen orbit is

A. 1.1×10^{-10} m
B. 1.7×10^{-10} m
C. 2.1×10^{-10} m
D. 2.7×10^{-10} m

36. A hydrogen atom emits light of wavelength 6.6×10^{-7} m when its electron falls to the level $n_f = 2$. The original energy state of the atom was

A. E_6
B. E_5
C. E_4
D. E_3

37. In a Rutherford-type experiment, which factor has the **least** effect on the large angle through which a few alpha particles are scattered?

A. The speed of the alpha particle
B. The presence of electrons in the scattering atoms
C. The charge on the nucleus of each scattering atom
D. The alpha particle's distance of closest approach to a scattering nucleus

38. A particle with a rest mass of 1.00×10^{-3} kg travels at the relativistic speed of 1.80×10^{8} m/s. Its kinetic energy is

A. 9.00×10^{13} J
B. 2.25×10^{13} J
C. 2.03×10^{13} J
D. 1.62×10^{13} J

39. When an electron in a hydrogen atom makes a transition from the fifth energy level to the second energy level, the momentum of the emitted photon is

A. 9.5×10^{-9} kg•m/s
B. 4.6×10^{-19} kg•m/s
C. 1.5×10^{-25} kg•m/s
D. 1.5×10^{-27} kg•m/s

40. Compton's experiments demonstrated that

A. X-rays diffract
B. photons have momentum
C. particles exhibit wave properties
D. atoms have discrete energy levels

41. The concept that particles exhibit wave-like properties was proposed by

A. de Broglie
B. Compton
C. Einstein
D. Planck

42. When a beam of electromagnetic radiation is used to determine the positions of atomic particles, the greatest accuracy is achieved by using radiation that has a

A. low intensity
B. high intensity
C. long wavelength
D. short wavelength

You have now completed Part A. Proceed directly to Part B.

Part B: Numerical Response

7 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**
- Use an HB pencil only.
- If you wish to change an answer, erase **all** traces of your first answer.

Sample Questions and Solutions

If the angle of incidence in air is 47.6° and the angle of refraction is 28.3°, the index of refraction is _____.
(Round and record your answer to three digits.)

$$n = \frac{\sin \theta_1}{\sin \theta_2}$$

$$n = \frac{\sin 47.6°}{\sin 28.3°} = 1.5576328$$

Record 1.56 on the answer sheet →

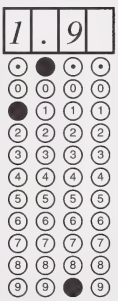
A microwave of wavelength 16 cm has a frequency of $b \times 10^9$ Hz. The value of b is _____.
(Round and record your answer to two digits.)

$f = c/\lambda$

$= (3.00 \times 10^8 \text{ m/s})/(0.16 \text{ m})$

$f = 1.875 \times 10^9$ Hz

Record 1.9 on the answer sheet →

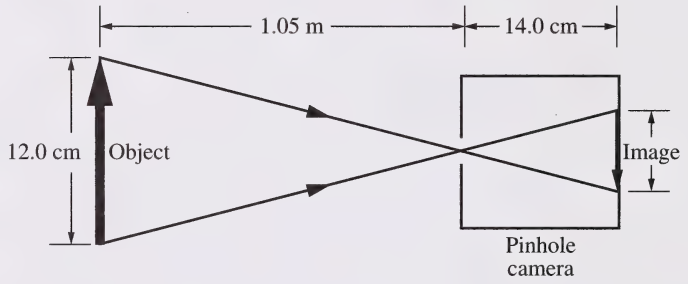


Start Part B immediately.

1. When light with a frequency of 6.00×10^{14} Hz enters a certain type of glass, its speed changes to 2.29×10^{8} m/s. The wavelength of the light in the glass is $\boldsymbol{b} \times 10^{-7}$ m. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

Use the following information to answer question 2.

Pinhole Camera



A pinhole camera produces an image of a 12.0 cm object.

2. The object is 1.05 m from the front of the camera and the camera is 14.0 cm long. The height of the image on the back of the camera is _____ cm.
(Round and record your answer to three digits.)

3. A current of 0.403 A flows for 3.04 min. The quantity of charge transferred is _____ C.
(Round and record your answer to three digits.)

4. At a distance of 2.00×10^4 m from the centre of an asteroid, the strength of the gravitational field is 2.74×10^{-2} N/kg. The mass of the asteroid, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ kg. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

5. A telecommunications transmitter sends out a microwave signal to a receiver and then receives it back after 1.330 s. The signal was in the receiver for 1.280 s before being returned. The distance between transmitter and receiver, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ km. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to two digits.)

6. As part of a Millikan experiment performed on the surface of the Earth, an oil drop of mass 1.20×10^{-15} kg is suspended in a vertical-uniform electric field of magnitude 3.70×10^{3} N/C. The charge on the oil drop is $\boldsymbol{b} \times 10^{-18}$ C. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

) YOUR ANSWER ON THE ANSWER SH

7. A metal has a work function of 5.87 eV. The threshold frequency, expressed in scientific notation, is $\boldsymbol{b} \times 10^{w}$ Hz. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

You have now completed Part B. Proceed directly to Part C.

Part C: Written Response

4 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized and appropriate manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Start Part C immediately.

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(5 marks)

Use the following information to answer question 1.

Many of the detectors that police use to measure the speed of moving vehicles utilize the Doppler effect. The Doppler frequency shift Δf is related to vehicle speed v by the equation:

$$\frac{\Delta f}{f} = \frac{v}{c}$$

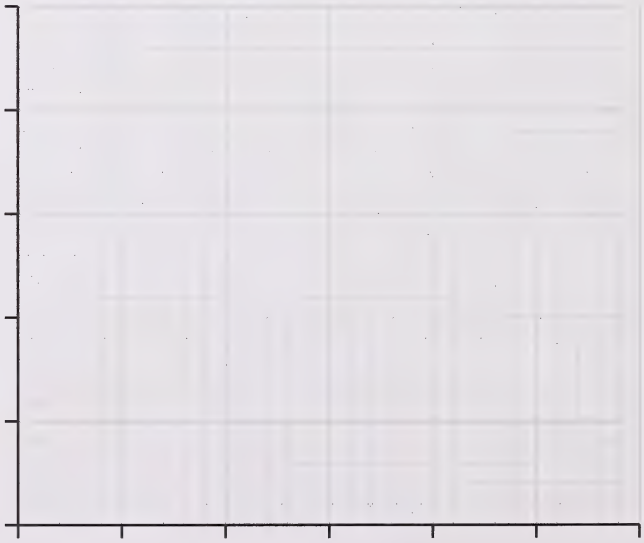
where f = carrier frequency and c = speed of light.

To calibrate the detector, measurements of Δf were made at six known values of v:

v (m/s)	Δf (kHz)
5.0	0.41
10.0	0.79
15.0	1.21
20.0	1.63
25.0	1.97
30.0	2.42

1. a. On the grid below, draw a graph of Δf as a function of v, with the manipulated variable on the horizontal axis. Provide a suitable title for your graph.

_____(title)



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b. Use a suitable averaging procedure to determine the carrier frequency f. Express your answer to two significant digits.

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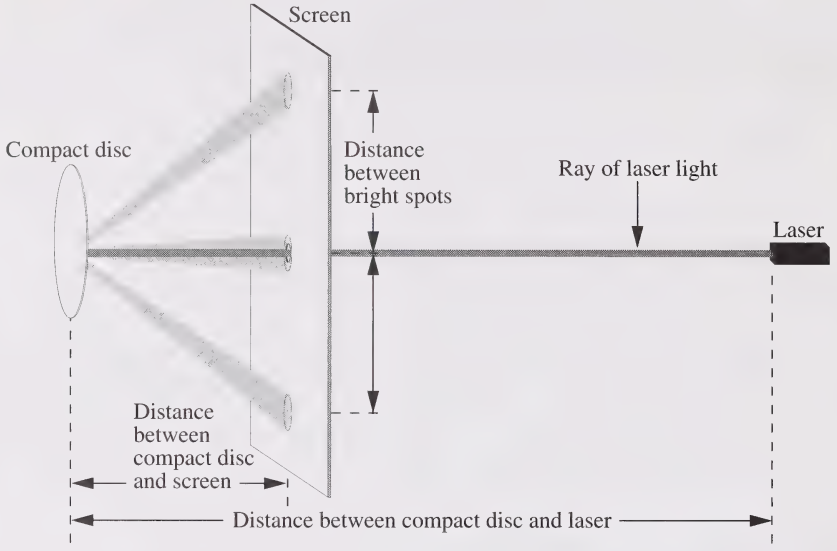
(5 marks)

Use the following information to answer question 2.

Students were curious to know how laser light behaves after it is normally incident upon the surface of a stationary compact disc. The compact disc has a smooth surface that is covered with many extremely tiny pits. The students set up the apparatus as shown. The diagram is not drawn to scale.



The laser light strikes the compact disc, which acts as a diffraction grating, and then forms an interference pattern of bright spots on the screen. The students used a helium-neon laser with a wavelength of 6.328×10^{-7} m, and then repeated the procedure using an argon laser with a wavelength of 4.87×10^{-7} m. They recorded the results.

Light source	Wavelength (10^{-7} m)	Distance between compact disc and screen (m)	Distance between compact disc and laser (m)	Distance between central and first bright spots (m)
Helium-neon laser	6.328	1.03	4.50	0.536
Argon laser	4.87	1.03	4.50	0.401

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2. Use data from both light sources to calculate the best estimate for the distance between the tiny pits on the surface of the compact disc. State any approximations or assumptions that you used in your estimation.

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(5 marks)

3. As part of a careful experiment involving circular electron orbits, an electron is accelerated until its measured charge-to-mass ratio is 8.89×10^{10} C/kg.

a. Why is this value for the charge-to-mass ratio different from the ratio 1.76×10^{11} C/kg derived from **Data Booklet** values?

b. Calculate the relativistic mass of the electron as found in this experiment involving circular orbits.

c. If the electron started from rest, calculate the accelerating voltage.

Be sure to turn the page and answer question 4.

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(6 marks)

Use the following information to answer question 4.

When a glass rod is rubbed with silk, the glass rod acquires a positive charge; when a rubber rod is rubbed with fur, the rubber rod acquires a negative charge.

4. Glass and rubber rods, silk and fur, and a metal-leaf electroscope are on hand. All of them are initially uncharged.

a. Explain how you would place a net positive charge on an uncharged electroscope by **conduction**, and describe the movement of charges that would occur at each stage. You **may** wish to include appropriately labelled diagrams as part of your explanation.

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b. Explain how you would place a net positive charge on an uncharged electroscope by **induction**, and describe the movement of charges that would occur at each stage. You **may** wish to include appropriately labelled diagrams as part of your explanation.

You have now completed the examination.
If you have time, you may wish to check your answers.

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No marks will be given for work done on this page.

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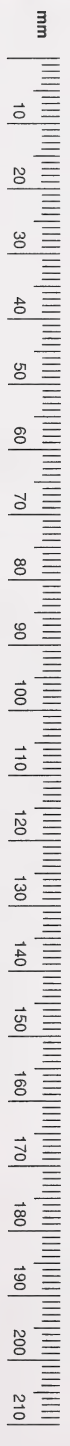

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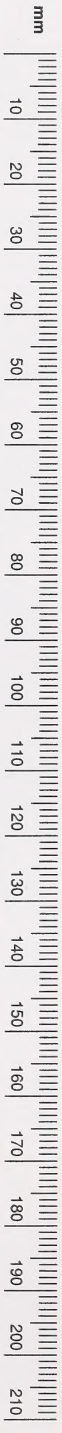

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Name

Apply Label With Student's Name

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(Last Name) (Legal First Name) Y M D

Name: **Date of Birth:** **Sex:**

Permanent Mailing Address: _____

(Apt./Street/Ave./P.O. Box) (Village/Town/City) (Postal Code)

School Code: **School:** _____ **Signature:** _____

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